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Picture Fuzzy Semi-Prime Ideals

Amal Kumar Adak[1,*], **Manish Kumar Gunjan**[2], **Nawin Kumar Agarwal**[2]

[1] Department of Mathematics, Ganesh Dutt College, Begusarai, Bihar, India; amaladak17@gmail.com.

[2] Department of Mathematics, Lalit Narayan Mithila University, Darbhanga, India; mgunjanmaths@gmail.com; amaladak217@gmail.com.

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Abstract

Picture Fuzzy Sets (PFSs) are expanded to include Intuitionistic Fuzzy Sets (IFSs), with the extra advantage of avoiding underlying limitations. PFS based models may be adequate in situations when we face opinions involving more answer of types: yes, abstain and no. In this paper, the concepts of semi-prime ideals of PFS are explained. We also discussed how to construct picture fuzzy regular and intra-regular ideals and represents certain fundamental facts.

Keywords: Intuitionistic fuzzy set, Picture fuzzy set, Picture fuzzy ideals, Picture fuzzy semi-prime ideals, Picture fuzzy regular ideals.

1 | Introduction

Zadeh [21] developed the fuzzy set methodology, that assigns a number from the unit range [0, 1] to each element of the discursive multiverse to indicate the degree of sense of belonging to the set under consideration using a degree of membership μ. Fuzzy sets are a subset of set theory that allows for states halfway between entire and nothing. A membership function is employed in a fuzzy set to represent the extent to which an element belongs to a class. The membership value can be anything between 0 and 1, with 0 indicating that the element is not a member of a class, 1 indicating that it is, and other values indicating the degree of membership. The membership function in fuzzy sets replaced the characteristic function in crisp sets. Fuzzy set theory has been applied to a variety of domains since Zadeh's seminal work, including artificial intelligence, management sciences, engineering, mathematics, statistics, signal processing, automata theory, social sciences, medical sciences, and biological sciences.

Because of the absence of nonmembership functions and the disregard for the potential of hesitation margin, the idea of fuzzy sets theory appears to be inconclusive. Atanassov [9] examined these flaws and created the concept of Intuitionistic Fuzzy Sets (IFSs) to address them. The construct (that is IFSs) combines the membership function, with the nonmembership function, ν, and the hesitation margin, π (that is neither membership nor nonmembership functions), resulting in $\mu+\nu\leq 1$ and

Corresponding Author: amaladak17@gmail.com.

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$\mu+\nu+\tau\leq 1$. IFSs give a versatile framework for elaborating uncertainty and ambiguity. IFS overcomes the defects of fuzzy set and can deal with fuzzy, uncertainty and incomplete information. There are lots work done in the field of IFSs [1], [2], [5], [11].

Although IFS has been successfully applied in many domains, it cannot handle inconsistent information in real life. Such as voting questions, all voting results can be divided into four groups that are "vote for", "abstain", "vote against" and "refuse to vote". In order to solve this type of issue, Picture Fuzzy Set (PFS) was proposed by Cuong [23]. PFS consists of three functions: positive membership function, neutral membership function and negative membership function. The PFS solved the voting problem successfully, and is applied to clustering, fuzzy inference, and decision-making.

Algebraic structures are important in mathematics. The concept of intuitionistic fuzzification of various semigroup ideals was introduced by Jun et al. [12]-[14]. Kim and Lee [15] gave the notion of intuitionistic fuzzy bi-ideals of semigroups. Manna et al. [3] have discussed on R-subgroup of near-rings. Adak et al. [4], [6]-[8], [22] present some results on pythagorean fuzzy ideal and Q-fuzzy ideals of near rings. Biswas [10] gives some properties of fuzzy subgroups. Yun [20] discussed on fuzzy ideal of ordered semi-group. Sardar et al. [18] gave the concept of intuitionistic fuzzy prime ideals, semi-prime ideals and also intuitionistic fuzzy ideal extension in a Γ -semigroup in [16], [17], [19].

In this paper, we introduce the notion of picture fuzzy subsemigroup, picture fuzzy left and right ideals of ordered semigroup. Also, we define picture fuzzy semi-prime ideals and picture fuzzy prime ideals. We investigate some important results picture fuzzysemi-prime ideals. The concepts of picture fuzzy left regular ideal and picture fuzzy right ideals are presented. Also, discussed important properties of these regular ideals.

The remainder of the paper is laid out as follows: preliminaries and definitions such as ordered set, ordered subgroups, IFSs, and PFSs are given in Section 2. In Section 3, we introduced some aspects of picture fuzzy prime ideals and semi-prime ideals as well as some of the important properties of picture fuzzy prime ideals. Section 4 concludes with a conclusion.

2 | Preliminaries and Definitions

We will review the related concepts of fuzzy sets, IFSs, and PFSs in this section. The definition of oredered set, ordered semigroup, prime ideal, semi-prime ideal are represented.

Definition 1 (Ordered Semigroup). A non empty set M is called an ordered semigroup if it is both an ordered set and a semigroup that meets the following criteria:

$a\leq b\Rightarrow xa\leq xb$ and $ax\leq bx$ *for all* $a,b,x\in M$.

Definition 2. Consider $(M,.,\leq)$ be an ordered semigroup. A non-empty subset G of M is called a subsemigroup of M if $G^2\subseteq G$.

Definition 3. Let P be a subset of an ordered semigroup M, that isn't empty. Then P is called a left (resp. right) ideal of M if it satisfies:

I. $MP\subseteq P$ (resp. $PM\subseteq P$).
II. $(\text{for all } p\in P)(\text{for all } q\in M),(q\leq p\Rightarrow q\in P)$.

P will be ideal of M if it is both left and right ideal of M.

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Definition 4. Let $(M,.,\leq)$ be an ordered semigroup and N be a non-empty subset of M. Then N is called prime if $pq \in N \Rightarrow p \in N$ or $q \in N$ for all $p,q \in M$.

Let N be an ideal of M, , if N is prime subset of M, then N is called prime ideal.

Definition 5. Let $(M,.,\leq)$ be an ordered semigroup and N be a non-empty subset of M. Then N is called semi-prime if $p^2 \in N \Rightarrow p \in N$ for all $p \in M$. Let N be an ideal of M. If N is a semi-prime subset of M, then N is called semi-prime ideal.

Definition 6. A fuzzy set F in a universal set X is defined as

$$F = \{< x, \mu_F(x) >: x \in X\},$$

where $\mu_F : X \to [0,1]$ is a mapping that is known as the fuzzy set's membership function.

The complement of μ is defined by $\bar{\mu}(x) = 1 - \mu(x)$ for all $x \in X$ and denoted by $\bar{\mu}$.

Definition 7. Let $(M,.,\leq)$ be an ordered semigroup. A fuzzy subset μ of M is called a fuzzy ideal of M, , if the following axioms are satisfied:

I. If $p \leq q$ then $\mu(p) \geq \mu(q)$.

II. $\mu(pq) \geq max\{\mu(p), \mu(q)\}$ *for all* $(p.q) \in M$.

Definition 8. Let X be a fixed set. An IFS A in X is an expression having the form

$$A = \{< x, \mu_A(x), w_A(x) >: x \in X\},$$

where the $\alpha_A(x)$ is the memebership grade and $\beta_A(x)$ is the non-membership grade of the element $x \in X$ respectively.

Also $u_A : X \to [0,1]$, $w_A : X \to [0,1]$ and satisfy the condition $0 \leq u_A(x) + w_A(x) \leq 1$ for all $x \in X$.

The degree of indeterminacy is $h_A(x) = 1 - u_A(x) - w_A(x)$.

Definition 9. Let $A = (u_A, v_A, w_A)$ be a PFS in M. Then $A = (u_A, v_A, w_A)$ is called picture fuzzy subsemigroup of M if it satisfies the following axioms:

I. $u_A(pq) \geq min\{u_A(p), u_A(q)\}$.

II. $v_A(pq) \leq max\{v_A(p), v_A(q)\}$.

III. $w_A(pq) \leq max\{w_A(p), w_a(q)\}$ *for all* $p,q \in M$.

Definition 10. A PFS $A = (u_A, v_A, w_A)$ in M is said to be picture fuzzy left ideal of M if following axioms are satisfied:

I. $p \leq q$ implies $u_A(p) \geq u_A(q)$ and $u_A(pq) \geq u_A(q)$.

II. $p \leq q$ implies $v_A(p) \leq v_A(q)$ and $v_A(p) \leq v_A(q)$.

III. $p \leq q$ implies $w_A(p) \leq w_A(q)$ and $w_A(pq) \leq w_A(q)$ *for all* $p,q \in M$.

Definition 11. A PFS $A=(u_A, v_A, w_A)$ in M is said to be picture fuzzy right ideal of M if following axioms are satisfied:

I. $p \le q$ implies $u_A(p) \ge u_A(q)$ and $u_A(pq) \ge u_A(p)$.

II. $p \le q$ implies $v_A(p) \le v_A(p)$ and $v_A(pq) \le v_A(q)$.

III. $p \le q$ implies $w_A(p) \le w_A(p)$ and $w_A(pq) \le w_A(q)$ *for all* $p, q \in M$.

A PFS $A=(u_A, v_A, w_A)$ is called a picture fuzzy ideal of M if it is left ideal as well as right ideal.

3 | Some Results on Picture Fuzzy Semi-Prime Ideals

This section introduces the notion of picture fuzzy prime ideal, picture fuzzy semi-prime ideal, picture fuzzy regular ideals and picture fuzzy intra-regular ideals of ordered semigroups. Also, prove some important results utilizing characteristic function of a non-empty subset of ordered semigroups.

Definition 12. A fuzzy subset μ of M is called prime, if

$$\mu(pq) = \max\{\mu(p), \mu(q)\} \text{ for all } p, q \in M,$$

where $(M, ., \le)$ be an ordered semigroup.

A fuzzy ideal μ of M is called a fuzzy prime ideal of M if μ is a prime fuzzy subset of M.

Definition 13. Let $A=(u_A, v_A, w_A)$ be a PFS in M. Then $A=(u_A, v_A, w_A)$ is called picture fuzzy prime of M if it satisfies the following axioms:

I. $u_A(pq) = max\{u_A(p), u_A(q)\}$.

II. $v_a(pq) = min\{v_A(p), v_A(q)\}$.

III. $w_A(pq) = min\{w_a(p), w_A(q)\}$ *for all* $p, q \in M$.

Definition 14. Let us consider μ be a fuzzy subset of an ordered semigroup M. If $\mu(p) \ge \mu(p^2)$ for all $p \in M$, then μ is called semi-prime. A fuzzy ideal μ of M is called a fuzzy semi-prime ideal of M if μ is a fuzzy semi-prime subset of M.

Definition 15. Let $A=(u_A, v_A, w_A)$ be a PFS in M. Then $A=(u_A, v_A, w_A)$ is called picture fuzzy semi-prime of M if following criterias are satisfied:

I. $u_A(p) \ge u_A(p^2)$.

II. $v_a(p) \le v_A(p^2)$.

III. $w_A(p) \le w_A(p^2)$ *for all* $p \in M$.

Theorem 1. For any picture fuzzy subsemigroup $A=(u_A, v_A, w_A)$ of M, if $A=(u_A, v_A, w_A)$ is picture fuzzy semi-prime, then $A(p) = A(p^2)$ holds.

Proof: Let p be an element of M. Since u_A is a fuzzy subsemigroup of M, then and so we have $u_A(p) = u_A(p^2)$.

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Also

$$u_A(p) \geq u_A(p^2) \equiv \min\{u_A(p), u_A(p)\} = u_A(p),$$

and

$$v_A(p) \leq v_A(p^2) \equiv \max\{v_A(p), v_A(p)\} = v_A(p),$$

thus $v_A(p) = v_A(p^2)$.

Also, we have

$$w_A(p) \leq w_A(p^2) \equiv \max\{w_A(p), w_A(p)\} = w_A(p),$$

thus $w_A(p) = w_A(p^2)$.

This proves the theorem. □

Definition 16. An ordered semigroup M is called left (resp. right) regular if, for each element a of M, there exists an element x in M such that $a \leq xa^2 (resp. a \leq a^2 x)$.

Theorem 2. Let M be left regular. Then, for every picture fuzzy left ideal $A = (u_A, v_A, w_A)$ of M, $P(p) = P(p^2)$ holds for all $p \in M$.

Proof: Let p be any element of M. Since M is left regular, there exists an element x in M such that $p \leq xp^2$.

Thus we have

$$u_A(p) \geq u_A(xp^2) \geq u_A(p^2) \geq u_A(p),$$

and so we have

$$u_A(p) = u_A(p^2).$$

Again

$$v_A(p) \leq v_A(xp^2) \leq v_A(p^2) \leq v_A(p),$$

thus

$$v_A(p) = v_A(xp^2).$$

Also, we have

$$w_A(p) \leq w_A(xp^2) \leq w_A(p^2) \leq w_A(p),$$

thus

$$w_A(p) = w_A(xp^2),$$

so, $P(p) = P(p^2)$.

This completes the proof. □

Theorem 3. Let M be left regular. Then, every picture fuzzy left ideal of M is picture fuzzy semi-prime.

Proof: Let $A = (u_A, v_A, w_A)$ be a picture fuzzy left ideal of M and let $p \in M$. Then, there exists an element x in M such that $p \leq xp^2$ since M is left regular. So, we have

$$u_A(p) \geq u_A(xp^2) \geq u_A(p^2),$$
$$v_A(p) \leq v_A(xp^2) \leq v_A(p^2),$$

and

$$w_A(p) \leq w_A(xp^2) \leq w_A(p^2).$$

This completes the proof. □

Definition 17. An ordered semigroup M is called intra-regular if, for each element p of M, there exist elements x and y in M such that $p \leq xp^2y$.

Definition 18. Let $A=(u_A,v_A,w_A)$ be a PFS in M. Then $A=(u_A,v_A,w_A)$ is called a picture fuzzy interior ideal of M if it satisfies axioms:

I. $x \leq y$ implies $u_A(x) \geq u_A(y)$ and $u_A(xsy) \geq u_A(s)$.
II. $x \leq y$ implies $v_A(x) \leq v_A(y)$ and $v_A(xsy) \leq v_A(s)$.
III. $x \leq y$ implies $w_A(x) \leq w_a(y)$ and $w_a(xsy) \leq w_A(s)$ *for all* $x, y \in M$.

Theorem 4. Let $A=(u_A,v_A,w_A)$ be a PFS in an intra-regular ordered semigroup M. Then, $A=(u_A,v_A,w_A)$ is a picture fuzzy interior ideal of M if and only if $A=(u_A,v_A,w_A)$ is an picture fuzzy ideal of M.

Proof: Let p,q be any elements of M, and let $A=(u_A,v_A,w_A)$ be a picture fuzzy interior ideal of M.

Then, since M is intra-regular, there exist elements x,y,p and in M such that $q \leq uq^2v$. Then, since u_A is a fuzzy interior ideal of M, we have

$$u_A(pq) \geq u_A((xp^2y)q) = u_A((xp)p(yq)) \geq u_a(p),$$

and

$$u_A(pq) \geq u_A(p(xq^2y)) = u_A((px)q(qy)) \geq u_A(q).$$

Again

$$v_A(pq) \geq v_A((xp^2y)q) = v_A((xp)p(yq)) \geq v_A(p),$$

and

$$v_A(pq) \geq v_A(p(xq^2y)) = v_A((px)q(qy)) \geq v_A(q).$$

Also, we have

$$w_A(pq) \geq w_A((xp^2y)q) = w_A((xp)p(yq)) \geq w_A(p),$$

and

$$w_A(pq) \geq w_A(p(xq^2y)) = w_A((px)q(qy)) \geq w_A(q).$$

On the other hand, let $A=(u_A,v_A,w_A)$ be a picture fuzzy ideal of M. Then, since u_A is a fuzzy ideal of M, we have

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$$u_a(xpy)=u_A(x(py))\geq u_A(py)\geq u_A(p),$$
$$v_a(xpy)=v_A(x(py))\leq v_A(py)\leq v_A(p),$$

and

$$w_a(xpy)=w_A(x(py))\leq w_A(py)\leq w_A(p).$$

For all x, a and $y\in M$.

This completes the proof. □

Theorem 5. Let $A=(u_A, v_A, w_A)$ be a picture fuzzy ideal of M. If M is intra-regular,then $A=(u_A, v_A, w_A)$ is picture fuzzy semi-prime.

Proof: Let p be any element of M. Then since M is intra-regular, there exist x and y in M such that $p\leq xp^2y$. So, we have

$$u_A(p)\geq u_A(xp^2y)\geq u_A(p^2y)\geq u_A(p^2),$$
$$v_A(p)\leq v_A(xp^2y)\leq v_A(p^2y)\leq v_A(p^2),$$

and

$$w_A(p)\leq w_A(xp^2y)\leq w_A(p^2y)\leq w_A(p^2).$$

This proves the theorem. □

Theorem 6. Let $A=(u_A, v_A, w_A)$ be a picture fuzzy interior ideal of M. If M is an intra-regular, then $A=(u_A, v_A, w_A)$ is a picture fuzzy semi-prime.

Proof: Let p be any element of M. Then since M is intra-regular, there exist x and y in M such that $p\leq xp^2y$.

$$u_A(p)\geq u_A(xp^2y)\geq u_A(p^2),$$
$$v_A(p)\leq v_A(xp^2y)\leq v_A(p^2y)\leq v_A(p^2),$$

and

$$w_A(p)\leq w_A(xp^2y)\leq w_A(p^2y)\leq w_A(p^2).$$

This proves the theorem. □

Theorem 7. Let M be intra-regular. Then, for all picture fuzzy interior ideal $A=(u_A, v_A, w_A)$ and for all $p\in M$, $A(p)=A(p^2)$ holds.

Proof: Let p be any element of M. Then since M is intra-regular, there exist x and y in M such that $p\leq xp^2y$. So, we have

$$u_A(p)\geq u_A(xp^2y)\geq u_A(p^2)\geq u_a((xp^2y)(xp^2y))=u_A((xp)p(yxp^2y)\geq u_A(p)),$$
$$v_A(p)\leq v_A(xp^2y)\geq v_A(p^2)\geq v_a((xp^2y)(xp^2y))=v_A((xp)p(yxp^2y)\leq v_A(p)),$$

and

$$w_A(p)\leq w_A(xp^2y)\geq w_A(p^2)\geq w_a((xp^2y)(xp^2y))=w_A((xp)p(yxp^2y)\leq w_A(p)).$$

So, we have $A(p)=A(p^2)$.

This completes the proof. □

Theorem 8. Let M be intra-regular. Then, for all picture fuzzy interior ideal $A=(u_A,v_A,w_A)$ and for all $p,q\in M$, $A(pq)=A(qp)$ holds.

Proof: Let p be any element of M. Then since M is intra-regular, there exist x and y in M such that $p\le xp^2y$. So, we have

$$u_A(pq)=u_A((pq)^2)=u_A(p(qp)q)\ge u_A(qp)=u_A((qp)^2)=u_A(q(pq)p)\ge u_A(pq),$$
$$v_A(pq)=v_A((pq)^2)=v_A(p(qp)q)\le v_A(qp)=v_A((qp)^2)=v_A(q(pq)p)\le v_A(pq),$$

and

$$w_A(pq)=w_A((pq)^2)=w_A(p(qp)q)\le w_A(qp)=w_A((qp)^2)=w_A(q(pq)p)\le w_A(pq).$$

So, we have $P(pq)=P(qp)$.

This proves the theorem. □

Definition 19. An ordered semigroup M is called archimedean if, for any elements p,q there exists a positive integer n such that $p^2\in M\,q\,M$.

Theorem 9. Suppose M be an ordered archimedean semigroup. Then, each picture fuzzy semi-prime fuzzy ideal of M is a constant function.

Proof: Let $A=(u_A,v_A,w_A)$ be any picture fuzzy semi-prime fuzzy ideal of M and $p,q\in M$. Then since M is archimedean, there exist x and y in M such that $p^n=xqy$ for some integer n.

Then, we have

$$u_A(p)=u_A(p^n)=u_A(xqy)\ge u_A(q),$$

and

$$u_A(q)=u_A(q^n)=u_A(xpy)\ge u_A(p),$$

and

$$v_A(p)=v_A(p^n)=v_A(xqy)\le v_A(q),$$

and

$$v_A(q)=v_A(q^n)=v_A(xpy)\le v_A(p),$$

also, we have

$$w_A(p)=w_A(p^n)=w_A(xqy)\le w_A(q),$$

and

$$w_A(q)=w_A(q^n)=w_A(xpy)\le w_A(p).$$

Therefore, we have

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$$P(p) = P(q), \text{ for all } p, q \in M.$$

This proves the theorem. □

4 | Conclusion

The PFS is an effective expansion of the IFS for dealing with knowledge uncertainty. In this context, we present the concepts of picture fuzzy prime ideals and semi-prime ideals of ordered semigroups in this study. Several of its appealing characteristics have also been studied. We also explore various findings on picture fuzzy regular ideals and intraregular ideals of ordered semigroups, along with promote the implementation of picture fuzzy regular ideals.

We'll look into the decision-making process more in the future. Interval-valued PFSs are being used to solve difficulties with uncertain data. An investigation of the interval-valued picture fuzzy will be conducted oredered semigroups, near-rings and interval-valued picture prime and semi-prime ideals, as well as their algebraic features.

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Conflicts of Interest

The authors declare that there is no competing of interests.

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